(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 May 2001 (25.05.2001)

PCT

(10) International Publication Number
WO 01/36753 A1

(51) International Patent Classification[7]: E02D 5/38

(21) International Application Number: PCT/GB00/04395

(22) International Filing Date:
17 November 2000 (17.11.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
9927241.1 18 November 1999 (18.11.1999) GB

(71) Applicant *(for all designated States except US)*: CEMENTATION FOUNDATIONS SKANSKA LIMITED [GB/GB]; Maple Cross House, Denham Way, Maple Cross, Rickmansworth, Herts WD3 2SW (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: SHOTTON, Peter, Gilbert [GB/GB]; 80 Straight Bit, Flackwell Heath, Bucks HP10 9NA (GB). PAYNE, Ron [GB/GB]; Cementation Foundations Skanska Limited, Maple Cross House, Denham Way, Maple Cross, Rickmansworth, Herts WD3 2SW (GB).

(74) Agent: HARMAN, Michael, Godfrey; Hillgate Patent Services, No. 6 Aztec Row, Berners Road, Islington, London N1 0PW (GB).

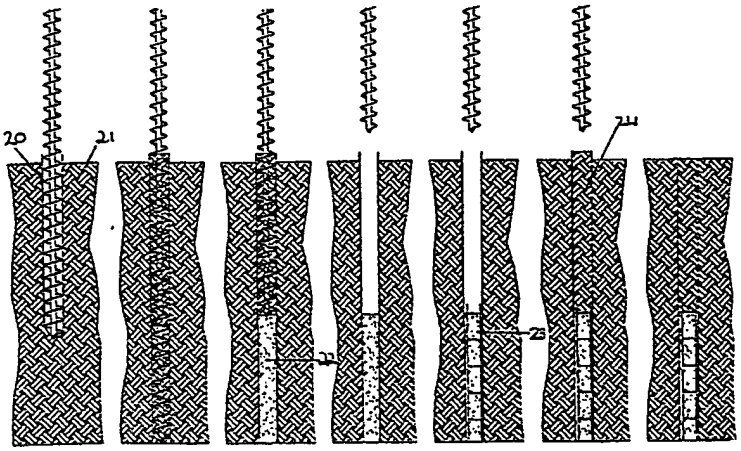
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).

Published:
— *With international search report.*

[Continued on next page]

(54) Title: PILE FORMING



(57) Abstract: A method of forming piles with a pile top level below ground level comprises the insertion of a casing into the ground so that the base of the casing is just below the desired pile top level, and the subsequent insertion of a continuous flight auger through the casing to form a pile therebelow by boring and injecting concrete in the conventional way. Where reinforcement is required, a continuous flight auger is disclosed incorporating closure means such as a rotating plate or hinged flaps at its lower end whereby the soil within the casing above the pile top level may be withdrawn therefrom by the auger after forming the pile, the reinforcement being subsequently introduced through the casing. Where no reinforcement is required, the injection of concrete may be halted and the rotation of the auger reversed once the pile has been formed to the desired pile top level, in order to backfill the hole above the pile top with soil during withdrawal of the auger. The casing may be removed together with or subsequent to the auger.

WO 01/36753 A1

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Pile Forming

The present invention relates to forming piles using continuous flight auger (CFA) methods, and more specifically to forming piles wherein the finished concrete is at some distance below the surrounding ground level.

A standard technique for forming a CFA pile is to screw the auger to the desired founding depth. The auger is fitted with a blade or flight which spirals helically around a hollow shaft, for the full length of the auger. The hollow shaft is used to pump concrete to the base of the auger, immediately filling the pile section while the auger is being withdrawn (so that the bore is never empty). The term "concrete" is used herein for any cementitious mixture containing also aggregate, water, and admixtures; such mixtures include mortar and concrete in the narrow sense.

A positive pressure and an excess concrete flow rate are maintained as the auger is steadily withdrawn, to ensure that the pile section is completely filled with concrete up to ground level, i.e. the level at which the piling plant is placed during construction of the piles. If required, after the auger has been fully withdrawn, reinforcing elements can be inserted into the concrete before it sets.

There are certain situations where the design requires that the head of the piles terminate at that reduced level. These situations particularly include projects where the general level of the site has to be reduced at a later date, e.g. to form a basement. Currently this is conventionally achieved by breaking down the excess height of piles during the excavation of the substructure. This requirement impedes the excavation of the

substructure and the breaking-down is costly. Additionally there is a risk that the construction plant carrying out the excavation may damage some of the piles; it is not unknown for a pile to be damaged or cracked below the final reduced level.

The object of the present invention is to provide an improved technique for constructing piles for such situations.

According to its main aspect, the invention provides a method of forming a pile with a finished concrete casting level (the pile top level) which is below ground level, comprising:

a) drilling a bore with a continuous flight auger and simultaneously inserting a casing at least until the pile top level is reached;

b) continuing drilling until the desired pile bottom level is reached;

c) withdrawing the auger and simultaneously injecting concrete until the pile top level is reached; and

d) filling the bore above the pile top level with soil and withdrawing the casing.

The invention thus provides a technique which permits the construction of continuous flight auger piles with a finished concrete casting level which is below ground.

If no reinforcement is required, step (d) may be performed by reversing the rotation of the auger as it is withdrawn through the casing.

If reinforcement is required, then between steps (c) and (d), the bore within the casing may be emptied and reinforcement introduced into the concrete below the pile top level. To achieve this, the auger may include closure means at its lower end with those closure means being actuated to withdraw the soil carried by the auger as the auger is withdrawn through the

casing. Alternatively, concrete injection may continue during withdrawal of the auger through the casing and the concrete in the casing is then removed; optionally, the removal of the concrete from within the casing may be performed by the auger. The casing is preferably inserted to slightly below the pile top level, to ensure that no soil enters the casing above the top pile level.

In the preferred forms of the invention, in order to construct a CFA pile with a cast concrete level which is below ground, a suitable length of casing is first inserted into the soil. The length of casing will be such that it extends to below the (future) head level of the concrete. The casing may be installed as a separate operation or concurrent with the flight auger boring the pile. The concrete is introduced in the conventional manner, i.e. under pressure, through the hollow stem and to the base of the CFA.

In one preferred form, where there is no requirement for any reinforcement to be placed in the pile, when the base of the auger reaches the required (low) concrete casting level during withdrawal, no further concrete is pumped through the auger. The auger is then rotated counter-clockwise and at the same time is withdrawn completely from the pile. This operation allows the soil which is on the flight to be discharged, thus avoiding any empty hole which would otherwise be left when the auger is completely withdrawn from the ground. The casing can be removed either together with the auger, or as a separate operation.

It is often desirable to install reinforcement in the pile.

In one preferred form, which allows reinforcement to be installed, the base of the auger is fitted with a mechanism which acts as a plug to prevent loss of soil from the auger when it is withdrawn through a casing or even the

soil. One form of plug may be one or more plates, preferably steel, which can be rotated to form a closure at the base of the auger. During the concreting phase, when the base of the auger is at the required (low) concrete casting level, no further concrete is pumped through the auger. The closure plug is activated, and the auger completely withdrawn. At this point in time the casing remains in position. The reinforcement is placed within the casing and pushed down to the required level, into the concrete. The casing may then be removed, either by means of a separate lifting appliance, or by the CFA rig. The potential void created by removal of the casing may be filled before or after the casing is withdrawn.

In another preferred form, which allows reinforcement to be installed, the pile forming technique and sequence is generally as described above, but the placement of concrete through the hollow stem continues until the auger has been completely removed. At this point in time the casing remains in position. Note that during the process of withdrawal, all soil, etc. is removed from the auger flight as it is being withdrawn. The auger is then used, with or without any attachment at the base, to remove the concrete from within the casing, down to the low casting level required. (In a modification of this form, the concrete injected into the casing is removed by a separate tool.) The reinforcement is placed within the casing and pushed down to the required level, into the concrete. The casing may then be removed, either by means of a separate lifting appliance, or by the CFA rig. The potential void created by removal of the casing may be filled before or after the casing is withdrawn.

The invention also provides an auger with closure means at its lower end. The closure means may comprise a plate rotatable through a restricted angle about the vertical axis of the auger, or a flap hinged to the leading edge of the flight of the auger.

Various methods of forming piles in accordance with the invention and pile forming machinery and augers therefor will now be described, by way of example, with reference to the drawings, in which:

Fig. 1 is a general view of the machinery;

Fig. 2 describes the sequence of operations according to one aspect of the invention;

Fig. 3 describes the sequence of operations according to another aspect of the invention;

Figs. 4A and 4B show an auger with closure means at its lower end; and

Figs. 5A and 5B show another auger with closure means at its lower end.

Fig. 1 shows pile forming machinery 10 consisting of a crawler unit 11 carrying a mast or column 12. The mast 12 has mounted on it an auger driving unit 13 which carries an auger 14. The driving unit 13 includes a motor for rotating the auger 14, and can also move itself up and down the mast. The auger passes through a guide collar 18 mounted on the bottom end of the mast 12. The auger 14 consists of a hollow central shaft 15 around which a continuous blade or flight 16 is attached, and may be formed from a number of sections bolted together. The mast 12 carries concrete supply tubing 17 at its top end, coupled to the top end of the auger shaft by flexible tubing (not shown).

Conventionally, during construction of a pile, the unit 13 rotates the auger clockwise and is lowered as the auger is screwed into the ground. When the auger has reached the desired depth, the unit 13 pulls the auger up out of the hole (with or without rotation). While the auger is being

withdrawn from the pile, a pump (not shown) pumps concrete down the hollow shaft 15 to fill the section vacated by the auger, thus forming the pile.

Fig. 2 shows one method of forming a pile with is upper end below ground level. A casing 20 is sunk in the ground 21, either as a separate operation or by means of the CFA rig (Fig. 2A). The auger is then screwed into the ground to the desired founding level (Fig. 2B). Concrete is then pumped through the hollow stem of the auger into the bottom of the bore 22 while the auger is gradually withdrawn (Fig. 2C). When the concrete has risen to the level of the bottom or toe of the casing, pumping is terminated, while the auger is completely withdrawn (Fig. 2D). If required, a reinforcing cage 23 is lowered into the casing and then pushed down to the required level in the concrete (Fig. 2E). Backfill 24 is placed in the void of the casing 20 (Fig. 2F) and the casing is then removed either by the CFA rig or as a separate operation (Fig. 2G).

Fig. 3 shows a modified method of forming a pile with is upper end below ground level. The method follows that of the Fig. 2 method except that the injection of concrete as the auger is withdrawn from the bore is continued until the auger is fully withdrawn, so that the casing 20 is filled with concrete (Fig. 3C), and the CFA auger or another suitable tool is then used to remove concrete from within the casing, down to the required level (Fig. 3D).

Figs. 4A and 4B show a method of achieving a seal at the base of the auger to retain the soil above the base of the auger. The auger has a baseplate 30 mounted on the vertical axis (i.e. the central bore 15) of the auger for rotation through a limited angle about that axis. When the auger is in the boring or drilling position, as shown in Fig. 4A, the clockwise rotation of the auger caries the baseplate to the position shown where the flight 16 of

the auger is open so that soil is carried up on the flight as the soil is dislodged. When the auger is rotated in the opposite direction, the baseplate turns about the central bore 15 to close the entrance to the auger flight, as shown.

Figs. 5A and 5B show a second form of auger with a closure member. The closure member consists of a flap 31 which is hinged on the top of the leading edge of the auger flight 16. During boring with clockwise rotation, the flat lies generally flat against the auger flight and causes essentially no obstruction to soil being gathered onto the auger flight. During anti-clockwise rotation, however, any movement of soil back down the auger flight will engage with the flap 31 and cause it to rise to the position shown in Fig. 4B, effectively closing off the auger flight.

Claims

1 A method of forming a pile with a finished concrete casting level (the pile top level) which is below ground level, comprising:

a) drilling a bore with a continuous flight auger and simultaneously inserting a casing at least until the pile top level is reached;

b) continuing drilling until the desired pile bottom level is reached;

c) withdrawing the auger and simultaneously injecting concrete until the pile top level is reached; and

d) filling the bore above the pile top level with soil and withdrawing the casing.

2 A method according to claim 1 wherein step (d) is performed by reversing the rotation of the auger as it is withdrawn through the casing.

3 A method according to claim 1 wherein, between steps (c) and (d), the bore within the casing is emptied and reinforcement is introduced into the concrete below the pile top level.

4 A method according to claim 3 wherein the auger includes closure means at its lower end and those closure means are actuated to withdraw the soil carried by the auger as the auger is withdrawn through the casing.

5 A method according to claim 3 wherein concrete injection continues during withdrawal of the auger through the casing and the concrete in the casing is then removed.

6 A method according to claim 5 wherein the removal of the concrete from within the casing is performed by the auger.

7 A method of forming a pile with a finished concrete casting level (the pile top level) which is below ground level substantially as herein described with reference to the drawings.

8 A pile with a finished concrete casting level (the pile top level) which is below ground level formed by the method of any previous claim.

9 An auger with closure means at its lower end.

10 An auger according to claim 9 wherein the closure means comprise a plate rotatable through a restricted angle about the vertical axis of the auger.

11 An auger according to claim 9 wherein the closure means comprise a flap hinged to the leading edge of the flight of the auger.

12 An auger substantially as herein described with reference to Figs. 4A and 4B or 5A and 5B.

13 Any novel and inventive feature or combination of features specifically disclosed herein within the meaning of Article 4H of the International Convention (Paris Convention).

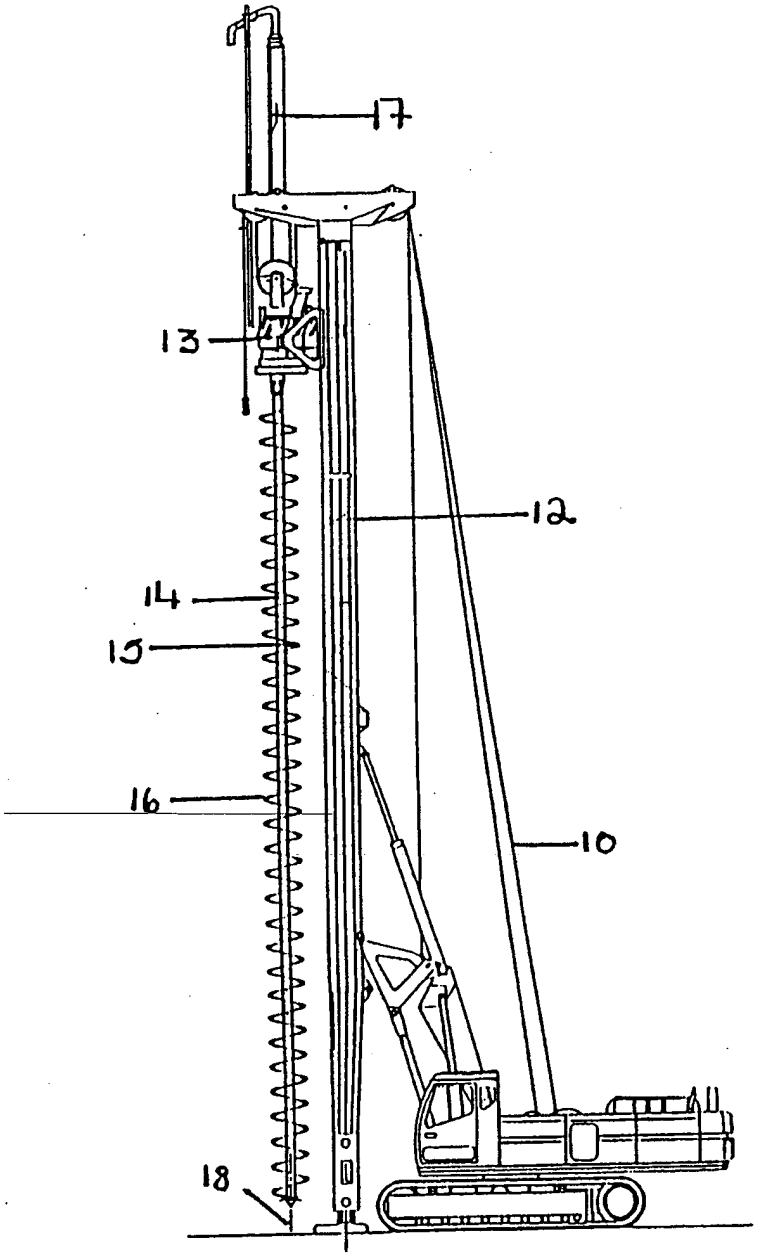


Figure 1

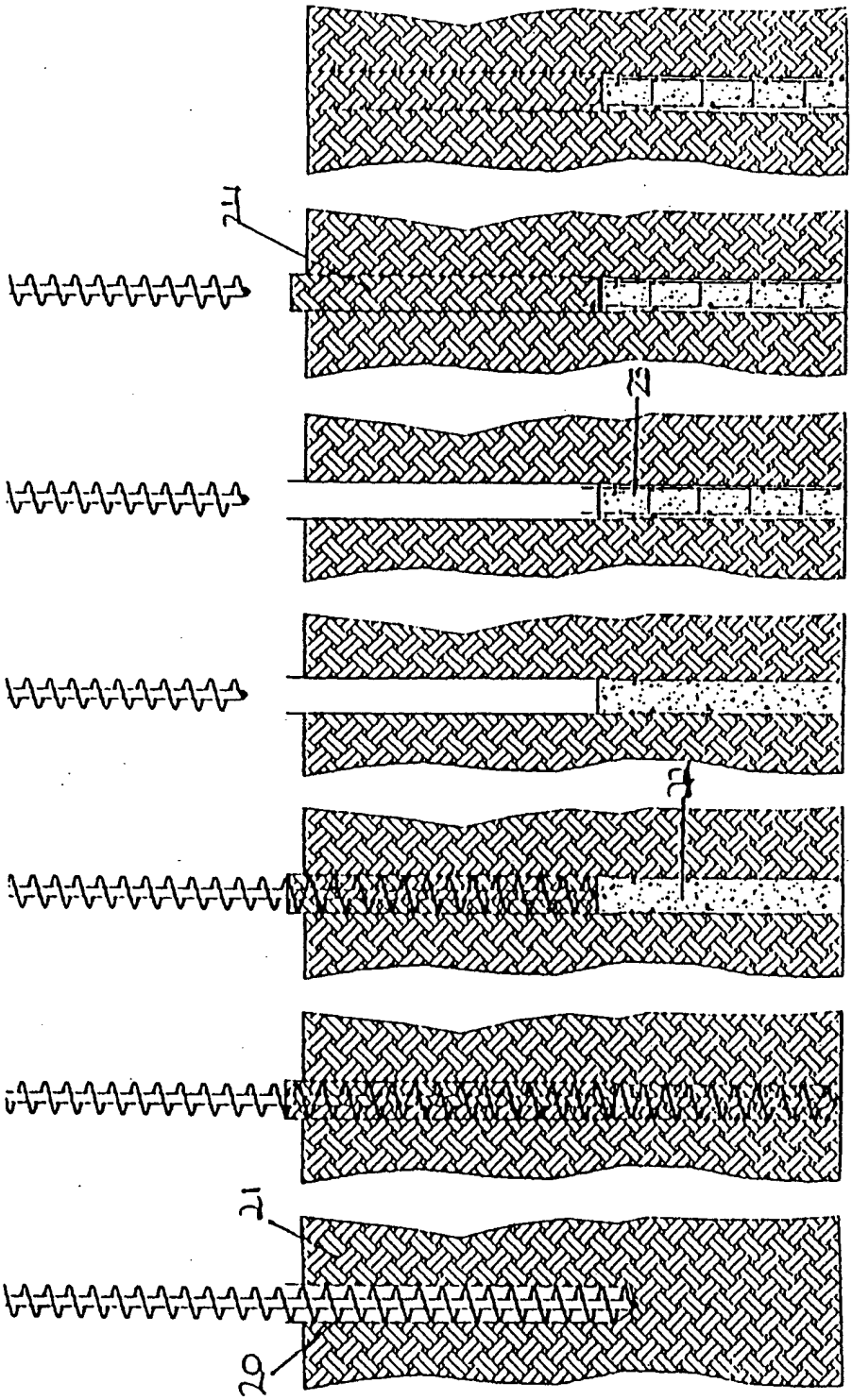


Figure 2

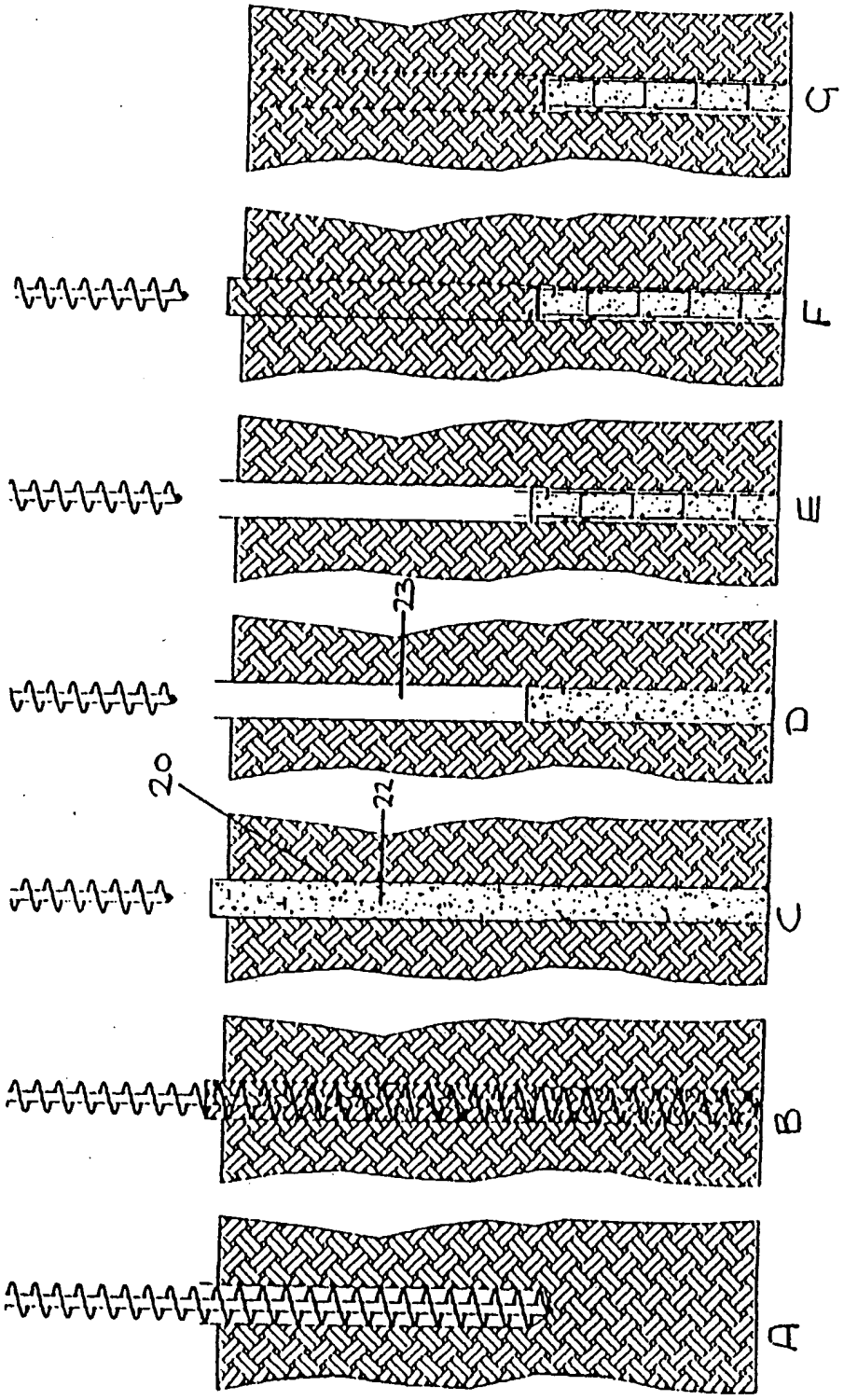


Figure 3

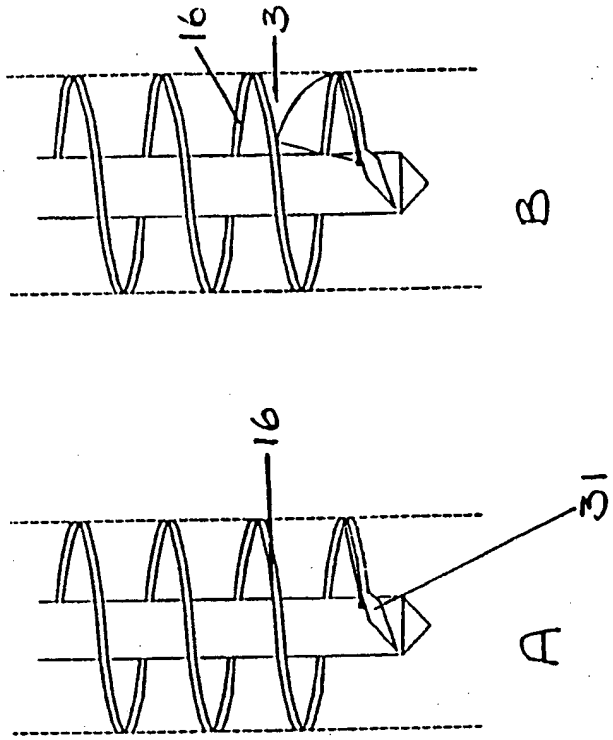


Figure 5

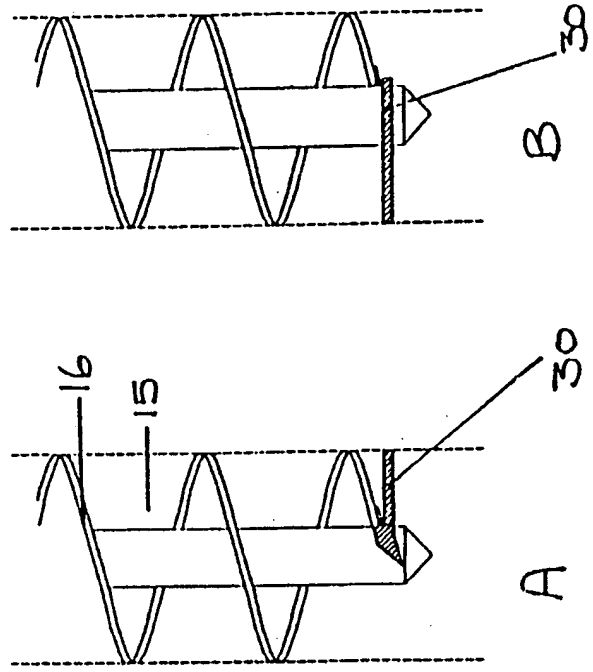


Figure 4

INTERNATIONAL SEARCH REPORT

Int ional Application No
PCT/GB 00/04395

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E02D5/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E02D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 261 891 A (PILECON ENGINEERING BERHAD) 2 June 1993 (1993-06-02)	1,2,9
Y	page 3, line 11 - line 25	4,6
A	page 4, line 27 -page 5, line 11; figures 1-3	3,5,7

Y	US 4 917 542 A (HICKEY EDWIN W) 17 April 1990 (1990-04-17)	4,6
A	column 1, line 36 -column 2, line 50; figures	1-3,5,7

X	DE 196 16 593 A (BAUER SPEZIALTIEFBAU) 6 November 1997 (1997-11-06)	10,11
A	claims; figures	5,12

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 February 2001	21/02/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Blommaert, S

1

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int :ional Application No
PCT/GB 00/04395

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2261891 A	02-06-1993	NONE	
US 4917542 A	17-04-1990	NONE	
DE 19616593 A	06-11-1997	NONE	